01/15/2017

MEMORANDUM FOR: Scott Carpenter
Western Region Fire Weather Program Manager
National Weather Service, Western Region

FROM: Andy Haner and Steve Reedy
Fire Weather Program Leaders
National Weather Service, Seattle, WA

SUBJECT: NWS Seattle's 2016 Annual Fire Weather Report

This report summarizes NWS Seattle's Fire Weather products and services in support of Western Washington land management agencies and public safety partners in the 2016 calendar year. This report addresses verification of Red Flag Warnings; verification of weather inputs into the National Fire Danger Rating System (NFDRS); Spot Forecast statistics; IMET dispatch information; and detailed information on fire weather training, liaison, and outreach activities.

The biggest in-house change in 2016 was training all 15 meteorologists at NWS Seattle to be able to work the Fire Weather Desk; previously only 6 meteorologists were trained to work the Fire Weather Desk. This effort entailed dozens of hours of pre-season staff time devoted to training that would prepare each forecaster to work the Fire Weather Desk. A concerted effort was also made to bring a diverse group of forecasters to springtime Fire Weather training and outreach activities (such as Fire Safety Refreshers) in order to become familiar with our firefighting partners. In the end, 13 out of 15 meteorologists independently worked one or more days on the desk between June and October of 2016.

Weather Synopsis:

Following the warm and wet winter of 2015-2016 that saw mountain snowpack melt off more quickly than usual, April-May 2016 were considerably warmer and *drier* than normal. This raised early concern that the early greenup --- and the unusually fast pace at which mountain snowpack was melting --- would lead to early curing and an early start to fire season. Indeed, western Washington saw its first Type 2 fires of the season during an east wind event in early May, which is unusually early for getting such active fire activity. To top it off, a 5-day heat wave occurred during the first week of June, boosting temperatures well into the 90s on June 5.

Following the early June heat wave, temperatures cooled back to near normal and remained there until late July. The lack of any more prolonged heat waves from mid-June through early August --- along with a handful of wetting rains in late June and July --- eased concerns and ultimately delayed the start of western Washington's more traditional summertime fire season. Despite the wet conditions, a cluster of thunderstorms over the Olympic Mountains sparked a complex of wildfires that would wait until August to become more active; this included the Godkin and Hayes Fires (pictured on last page).

A prolonged period of warm, dry weather finally developed around August 12. It took about 5 days of warm, sunny weather to finally dry fuels to the point of meeting the prerequisite level of dryness needed for Red Flag Warnings. After fuels had dried out, there were two episodes of hot and dry weather

concurrent with moderate breezes from August 18-20, and again from August 24-25. This represented the peak of the 2016 fire season in western Washington. Indeed, the Godkin Fire burned actively during this time.

No more 80-degree days were observed at Sea-Tac after August 26; the last 80-degree day more commonly occurs around Sep. 13. So with no more prolonged periods of warm weather --- along with a widespread wetting rain around September 6, western Washington's 2016 fire season slowly declined through most of September.

So in summary, there was only about a 2-week window in mid-late August during which weather and fuels lined up to support critical fire weather conditions. There was no mass ignition event (i.e. lightning event) during this critical 2-week period.

2016 Fire Weather Watch / Red Flag Warning Verification:

Red Flag events in the Seattle Fire Weather district consist of 1) scattered lightning, 2) a combination of a moderate breeze and low relative humidity, or 3) a dry and unstable atmosphere – in combination with dry fuels. When fuels have reached a pre-requisite level of dryness, Red Flag events are determined using lightning data, surface observations (mainly RAWS and ASOS sites), and upper air data. Impacts - such as growth on existing fires and new ignitions - are also considered.

One of the major goals for 2016 was to correct the under-warning for lightning which took place in 2015. However, 2016 was the first season since 2011 with no scattered-or-greater lightning events concurrent with sufficiently dry fuels, so we will wait until 2017 to gage our success in correcting this issue.

The window of time during which fuels met prerequisite dryness levels was fairly short this year, encompassing only about two weeks during the second half of August.

August 18-20
Red Flag Warnings (RFWs) issued for moderate breezes and low relative humidity on Aug. 18-19, then a dry and unstable air mass over the mountains on 8/20. Many Fire Weather zones waited until August 19 to observed Red Flag conditions, resulting in excellent warning lead times. The Godkin and Hayes Fires in Olympic National Park grew by hundreds of acres on 8/19.
Warnings = 11, Verified = 9, Unverified = 2, Missed Events = 0, average lead time = 35 hours

August 24-25
RFWs issued for a marginal event of moderate breezes and low RH over much of the Puget Sound Lowlands and the northwest Olympic Peninsula. Red Flag conditions developed in several zones sooner than expected on 8/24, resulting in zero-hour lead times.
Warnings = 4, Verified = 3, Unverified = 1, Missed Events = 0, average lead time = 0 hours

For the whole fire season, the Probability of Detection (POD) --- or the percent of observed events covered by a RFW --- was 100%! False Alarm Rate (FAR) was only 20%.

2016 Stats…

Red Flag Warnings	- 15 issued - 12 verified - 0 unwarned events
Average lead-time of Red Flag events	- 22.7 hours
# Of Red Flag Warnings issued = a + c	= 15
# Of Red Flag Warnings that verified = a	= 12
# Of Red Flag Warnings that did not verify = c	= 3

Of observed events with no RFW issued = b = 0

Probability of Detection (POD)	= a/(a+b)	= 12/(12+0)	= 1.00 = 100%
False Alarm Rate (FAR)	= 1 - (a/(a+c))	= 1 – (12/(12+3)	= 0.20 = 20%
Critical Success Index (CSI)	= a/(a+b+c)	= 12/(12+0+3)	= **0.80**

2016 NFDRS Weather Forecast Verification:

NWS Seattle plays a key role in the National Fire Danger Rating System (NFDRS) by providing forecast weather inputs for use in producing the next day's forecast fire danger indices. Therefore, forecast accuracy has a direct impact on the accuracy of forecast fire danger indices. NWS weather inputs are verified by computing the percent improvement of the NWS forecast over a persistence forecast; a persistence forecast simply assumes that tomorrow's weather will be the exact same as today's weather.

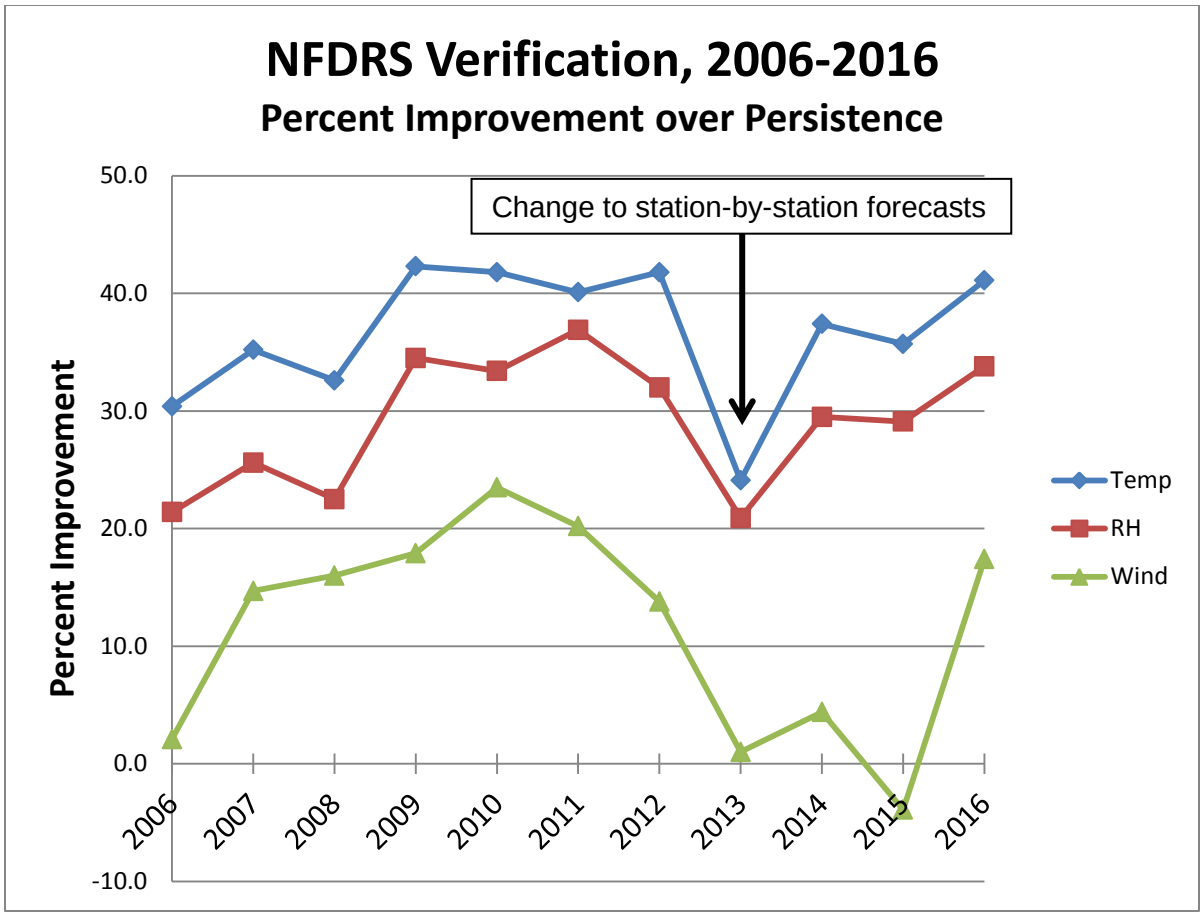
NWS Seattle's NFDRS weather forecasts reached a milestone in 2016 by re-gaining scores that were commonly achieved prior to 2013 when NWS Seattle issued zone-based forecasts, in contrast to the more challenging station-based forecasts which began in 2013. When this change was made, it was anticipated that verification scores would drop for a few years, and they did. It was also anticipated that scores would rebound in the following years as forecasting improved and better bias corrections were applied to each individual station's forecast. By reaching this milestone in 2016, the switch to station-by-station forecasts has now achieved the vision of providing a forecast that better represents each individual station in western Washington, as opposed to broader zone-sized areas that do not well represent the nuances of each individual station.

Wind speed forecasts showed a huge improvement in 2016, versus the poor performance of 2015. This was the result of two efforts: 1) At nearly half of the RAWS stations, we started forecasting a single climatological wind speed each day; this is an effective technique at stations which do not show a large range of wind speeds. 2) Early in fire season, we checked for stations which were experiencing a change in the character of wind speeds compared to recent years, which was the root cause for our poorest performing wind forecasts in 2015. For example, we were able to re-calibrate our forecast for Greenwater RAWS after the site showed much stronger wind speeds following an off-season timber harvest. Meanwhile, we better adjusted for stations like Ohanapecosh and Hozomeen, where observed wind speeds dropped off into the 0-1 mph range.

Temperature:
Percent improvement over persistence forecast: 41.1%
Compared to 2006-2015 average: 5.0% better

Relative Humidity:
Percent improvement over persistence: 33.8%
Compared to 2006-2015 average: 5.2% better

Wind Speed:
Percent improvement over persistence:
Compared to 2006-2015 average: 6.4% better



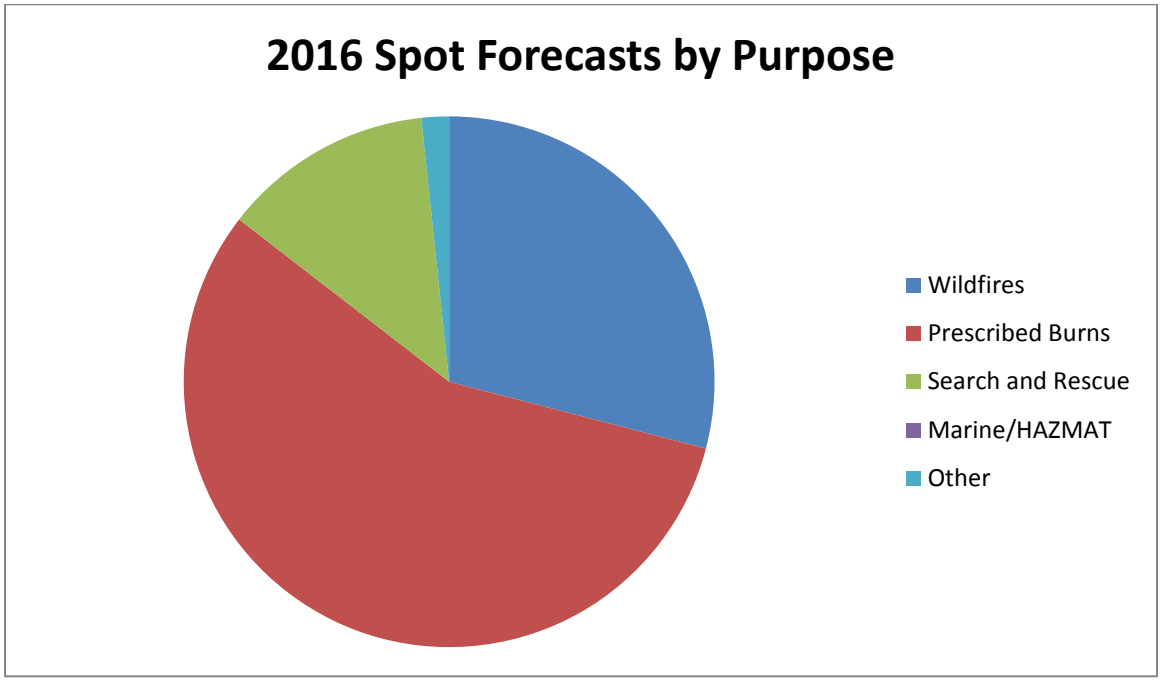
Annual NFDRS Weather Forecast Verification												
Temperature					Relative Humidity				Wind Speed			
Year		MAE(f)	MAE(p)	%IMPV		MAE(f)	MAE(p)	%IMPV		MAE(f)	MAE(p)	%IMPV
1995		3.3	4.9	32.6		8.8	11.3	22.1		1.7	1.9	10.5
1996		3.0	5.4	44.4		7.8	11.0	29.1		1.8	2.0	10.0
1998		3.4	5.5	38.2		8.1	11.6	30.2		1.6	1.6	0.7
1999		3.8	6.1	37.3		9.0	12.9	30.3		1.5	1.5	0.7
2000		3.6	5.2	30.7		8.6	11.7	26.5		1.6	1.6	0.0
2001		3.5	4.4	21.6		8.1	10.0	18.7		1.6	1.8	6.3
2002		3.4	4.9	30.6		8.0	10.7	24.8		1.7	1.9	10.8
2003		4.1	5.5	25.0		9.2	11.3	16.7		1.9	1.9	-3.9
2004		3.8	4.9	22.4		9.2	11.5	19.6		1.6	1.8	5.0
2005		3.8	5.4	30.0		9.5	12.6	23.5		1.5	1.6	4.2
2006		3.9	5.6	30.4		8.7	11.2	21.4		1.5	1.6	2.1
2007		3.6	5.5	35.2		9.0	12.5	25.6		1.4	1.6	14.7
2008		3.6	5.5	32.6		9.1	12.0	22.5		1.7	2.1	16.0
2009		3.4	6.0	42.3		8.4	13.0	34.5		1.4	1.8	17.9
2010		3.1	5.4	41.6		7.9	12.0	33.2		1.5	2.0	23.3
2011		3.1	5.1	39.7		7.6	12.2	36.8		1.5	2.0	20.9
2012		3.2	5.5	41.8		7.8	11.6	32.0		1.2	1.5	13.8
2013		4.0	5.4	23.9		9.6	12.5	21.0		1.8	1.8	1.0
2014		3.7	5.1	37.4		9.2	13.3	29.5		1.6	1.8	4.4
2015		3.7	6.0	35.7		9.2	13.2	29.1		1.6	1.8	-3.9
2016		3.4	5.9	**41.1**		8.9	13.6	**33.8**		1.6	1.9	**17.4**

Zone	Station	Mean Absolute Error of 2016 Forecasts/Weather Inputs						MAE (Persistence)			% Impv. Over Persistence		
		T	*T Bias*	***RH***	*RH Bias*	***WS***	*WS Bias*	*T*	*RH*	*WS*	*T*	*RH*	*WS*
649	Quillayute (UIL)	**2.9**	-0.7	**9.0**	-0.6	**2.5**	1.6	4.5	12.8	2.6	36	30	5
649	Hoquiam (HQM)	**2.4**	0.5	**8.0**	-4.1	**2.5**	-0.4	3.8	11.8	3.6	37	32	31
650	Forks	**2.9**	0.4	**8.2**	-2.4	**1.0**	-0.3	5.6	14.1	1.3	48	42	25
650	Ellis Mtn	**3.7**	0.4	**9.9**	-3.9	**2.3**	0.1	6.3	14.6	3.4	41	32	34
650	Black Knob	**2.6**	0.9	**9.5**	-6.9	**1.1**	0.5	5.5	14.1	1.3	53	32	13
651	Minot Peak	**5.5**	4.9	**9.6**	-4.0	**1.7**	-0.2	5.7	15.4	2.3	4	37	27
652	Toms Creek	**2.9**	2.0	**9.0**	-6.1	**1.6**	0.1	5.1	12.8	1.4	42	30	-12
652	Owl Mtn	**3.8**	2.5	**10.8**	-8.1	**1.4**	-0.3	5.8	12.6	1.8	35	14	21
652	Humptullips	**3.8**	2.4	**9.3**	-6.0	**2.0**	-1.3	6.3	13.2	2.3	39	30	13
653	Whidbey (NUW)	**2.7**	0.1	**7.8**	1.2	**2.5**	-1.5	3.1	9.2	3.0	14	15	16
653	Bellingham (BLI)	**2.4**	-0.1	**7.4**	-0.6	**1.9**	-0.5	3.8	10.1	3.2	37	27	41
653	Everett (PAE)	**2.2**	0.4	**6.9**	-1.2	**2.6**	0.3	4.3	10.5	3.1	48	35	15
654	Quilcene	**3.4**	-0.6	**8.3**	-1.6	**1.0**	-0.4	5.5	13.1	1.2	37	37	19
654	Bremerton (PWT)	**3.1**	0.4	**8.5**	-2.4	**2.2**	-0.7	5.9	14.0	3.1	48	39	29
654	Seattle (SEA)	**2.7**	-0.5	**7.5**	-0.7	**2.1**	-0.2	4.7	11.0	3.1	42	32	30
654	Tacoma (TCM)	**2.3**	0.1	**7.7**	-3.9	**2.8**	0.3	4.3	11.4	4.0	46	33	30
655	Olympia (OLM)	**2.7**	-0.4	**7.6**	0.5	**2.0**	-0.7	5.0	11.9	3.7	45	36	46
655	Chehalis RAWS	**4.7**	-0.4	**10.0**	-3.0	**1.3**	-0.1	5.6	11.7	1.5	15	14	10
656	Marblemount	**3.9**	-1.3	**9.6**	-3.2	**1.6**	0.0	7.3	14.9	1.7	47	36	6
656	Sedro Woolley	**3.0**	-0.5	**7.6**	-2.0	**1.2**	-0.5	5.0	11.0	1.4	40	31	10
657	Enumclaw	**2.9**	-0.6	**7.6**	-3.8	**1.2**	-0.5	4.9	10.8	1.5	40	30	22
657	Ashford	**3.1**	-1.5	**7.5**	-1.7	**0.8**	0.2	6.3	14.4	1.1	50	48	21
658	Kidney Creek	**M**	M	**M**	M	**0.6**	0.0	10.8	14.3	0.8	M	M	28
658	Hozomeen	**4.7**	-2.9	**9.9**	-0.6	**0.5**	-0.5	7.2	16.4	0.8	34	40	30
658	Sumas Mtn	**3.8**	0.8	**9.5**	-3.9	**1.6**	-0.4	6.4	13.4	1.7	40	29	5
658	Finney Creek	**3.5**	1.1	**10.2**	-5.5	**1.0**	-0.3	6.3	12.7	1.3	44	19	21
658	Johnson Ridge	**4.0**	1.4	**10.1**	-5.8	**1.5**	0.6	7.8	15.4	1.7	49	35	8
658	Gold Hill	**2.9**	0.3	**8.6**	-2.8	**0.8**	-0.1	6.4	14.1	1.0	55	39	18
659	Kosmos	**3.7**	-0.7	**9.8**	-4.4	**0.4**	0.0	7.0	15.6	0.6	47	37	31
659	Hager Creek	**3.8**	-0.8	**9.4**	-3.4	**0.6**	0.1	7.7	17.1	0.6	50	45	0
659	Ohanapecosh	**5.2**	-3.6	**9.9**	-3.7	**0.4**	0.2	7.5	16.4	0.4	30	40	0
659	Lester	**3.1**	-0.9	**7.3**	-3.1	**1.2**	-0.4	6.4	13.8	1.4	51	47	15
659	Stampede Pass (SMP)	**3.3**	1.1	**9.7**	-3.2	**1.4**	-0.1	6.6	16.6	2.0	51	42	31
659	Greenwater	**3.9**	-1.4	**8.1**	-0.4	**5.0**	-4.3	6.7	14.2	4.5	43	43	-10
659	Fire Training Academy	**3.2**	1.6	**8.5**	-4.9	**1.9**	-1.2	5.8	13.2	1.7	45	36	-10
659	Orr Creek	**4.3**	-0.5	**9.7**	-4.2	**0.5**	0.1	8.3	17.0	0.6	48	43	20
661	Cougar Mtn	**2.5**	0.5	**8.8**	-2.2	**1.0**	0.2	4.8	13.9	1.2	47	37	18
661	Hurricane RAWS	**3.3**	1.1	**11.8**	-6.4	**2.6**	-1.2	5.1	14.9	2.6	36	21	1
661	Buck Knoll	**2.8**	-0.2	**8.2**	-1.5	**1.0**	0.2	5.6	15.1	1.2	51	45	18
661	Jefferson	**3.2**	0.4	**9.6**	-2.2	**1.4**	0.1	6.4	15.0	2.0	50	36	30
662	Stehekin	**4.1**	0.1	**8.8**	-0.7	**2.1**	-1.4	6.1	12.3	2.3	32	28	8
*Station-Based **Averages***		***3.4***		***8.9***		***1.6***		***5.9***	***13.6***	***1.9***	***41.1***	***33.8***	***17.4***

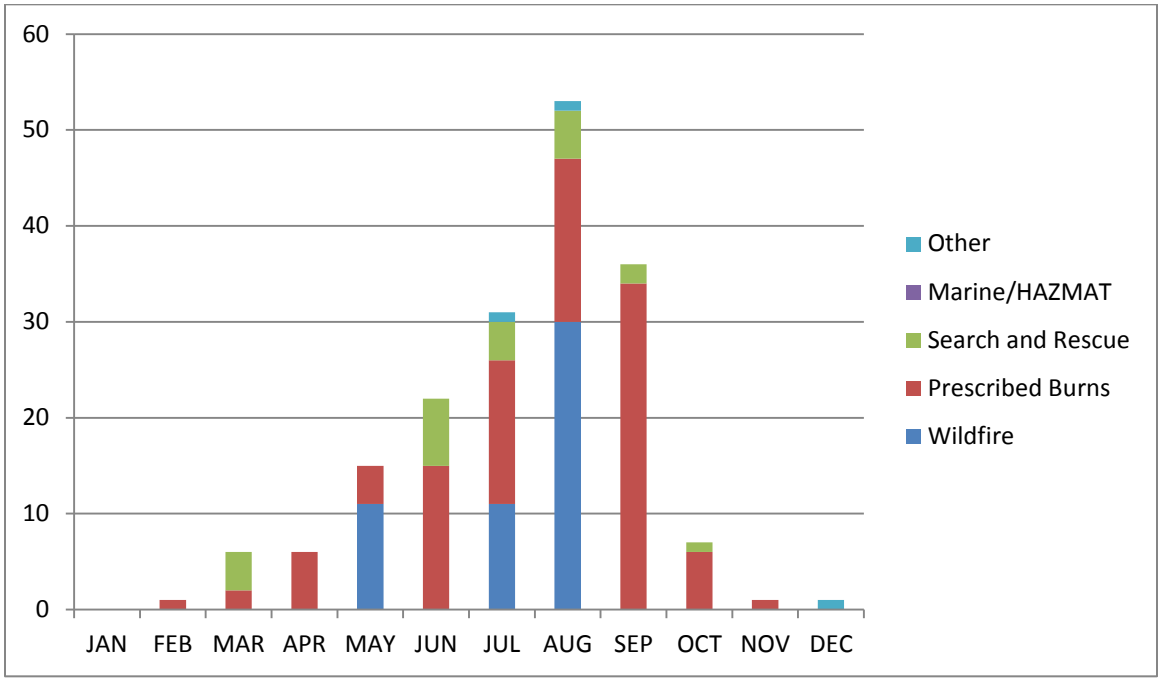
2016 Spot Forecasts:

NWS Seattle issued 179 Spot Forecasts in 2016. Spot Forecasts supported wildland fires, prescribed burns, Search and Rescue missions, and public events. This is the fewest Spot Forecasts since 2013, when 142 were issued. This is not surprising given the historically busy 2014 and 2015 wildfire seasons, years in which 210 and 314 Spot Forecasts were issued respectively. All categories saw declines in numbers from 2015.

Purpose	# of Spots
Wildfire	52
Prescribed Burns	101
Search and Rescue	23
Marine/HAZMAT	0
Other	3



Breakdown of 2016 Spots Forecasts by Month



2016 IMET Dispatches

In 2016, NWS Seattle **I**ncident **Met**eorologists (**IMET**s) and IMET Trainees responded to **2 dispatches** totaling 17 days of on-site weather support, plus partial days and travel. They were:

Dates	IMET	Location	Incident
8/2 – 8/4	**Haner**	**Benton City, WA**	**Range 12 Fire**
8/25 – 9/7	**Bower**	**Salinas, CA**	**Soberanes Fire**

Training, Liaison, and Outreach Activities in 2016:

Following historically busy fire seasons for the Pacific Northwest in 2014 and 2015, interest was high in weather training for firefighters during the 2016 pre-season training push. NWS Seattle committed **38 staff-days** in 2016 in direct support of fire weather training, liaison, or outreach activities. These efforts directly reached **1,322 people** in attendance at these events. The table below lists the activities.

Date	Forecaster	Location	Activity
3/5/16	**Haner**	**Seattle, WA**	**Fire Talk at Pacific Northwest Weather Workshop (~100 Attendees)**
3/21-23	**Haner, Buehner**	**Duvall, WA**	**S-290 Instruction (10 Attendees)**
3/26	**Haner**	**Burlington, WA**	**Fire Weather Introduction (18 Attendees)**

3/28-29	**Haner**	**Vancouver, WA**	**Wa/Ore IMT Training and FBAN/IMET Breakout (38 heard presentation)**
4/11	**Haner, Michalski**	**North Bend, WA**	**Fire Safety Refresher (31 Attendees)**
4/13	**Reedy, Mercer**	**Sedro Woolley, WA**	**Fire Safety Refresher (35 Attendees)**
4/16-17	**Haner**	**Anacortes, WA**	**Fire Safety Refresher for Structure Crew (22 Attendees)**
4/18	**Haner, Reedy, Buehner**	**NWS Seattle, WA**	**Annual Fire Weather Users' Meeting, held online (75 Attendees)**
4/20-21	**Haner**	**Portland, OR**	**Annual GACC-NWS Meeting**
4/27	**Haner**	**Portland, OR**	**Pacific Northwest Regional Dispatchers' Workshop (120 Attendees)**
5/4	**Haner**	**Sedro Woolley, WA**	**Fire Safety Refresher for Baker River Hotshots (20 Attendees)**
5/5	**Haner**	**Port Angeles, WA**	**Fire Safety Refresher (28 Attendees)**
5/7	**Haner**	**Big Lake, WA**	**Fire Weather Introduction and Fire Safety Refresher (13 Attendees)**
5/11	**Haner**	**Camp Murray, WA**	**Wildfire Talk for State Emergency Management Division (160 Attendees)**
5/16	**Haner, Albrecht**	**North Bend, WA**	**Fire Safety Refresher (29 Attendees)**
5/17	**Haner**	**Ashford, WA**	**Columbia Crest STEM Fair, RAWS Visit (160 attendees)**
5/18	**Haner, McFarland**	**Sedro Woolley, WA**	**Fire Safety Refresher (40 Attendees)**
5/23	**Haner, Bower**	**Everett, WA**	**Visit to Puget Sound Interagency Communication Center (4 Dispatchers)**
5/24-25	**Haner**	**Sedro Woolley, WA**	**S-290 Instruction (25 Attendees)**
5/26	**Haner, Schneider, Juarnic, Churchill**	**Ohanapecosh, WA**	**Fire Safety Refresher (32 Attendees)**
6/1	**Buehner**	**Edgewood, WA**	**Fire Season Outlook for Pierce County Fire Chiefs**

			(30 Attendees)
6/1	**Haner, Cushmeer, Smith**	**Port Angeles, WA**	**Fire Safety Refresher (32 Attendees)**
6/15	**Buehner**	**Tacoma, WA**	**Fire Season Outlook/ Summer Weather Planning Meeting for EMs (40 Attendees)**
6/16	**Haner, Gaebel**	**Marblemount, WA**	**Fire Safety Refresher (34 Attendees)**
6/20	**Haner**	**North Bend, WA**	**Fire Safety Refresher (18 Attendees)**
6/21	**Haner, Buehner**	**Rainier, WA**	**S-290 Instruction at DNR Wildfire Academy (49 Attendees)**
6/22	**Haner, Smith**	**Sedro Woolley, WA**	**Fire Safety Refresher (24 Attendees)**
6/24	**Haner**	**Rainier, WA**	**S-190 Instruction at DNR Wildfire Academy (82 Attendees)**
6/25	**Haner**	**Anacortes, WA**	**S-190 Instruction (36 Attendees)**
6/30	**Haner, Buehner**	**Seattle, WA**	**Wildfire Awareness Media Tour (17 Media Members Contacted)**

Hayes Fire as seen looking south from Hurricane Ridge in Olympic National Park, August 24, 2016